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UNITED STATES DEPARTMENT OF AGRICULTURE

BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE

FOREST INSECT INVESTIGATIONS

MEMORANDUM FOR THE FILES

RE: WINTER KILLING OF PINE FOLIAGE

by
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Forest Insect Laboratory
Coeur d'Alene, Idaho
April 23, 1937

U. S. GOVERNMENT PRINTING OFFICE 60918

Mr. Keen

Forest Insect Laboratory
Coeur d'Alene, Idaho
April 28, 1937

Refer to file
Studies C-8

Dr. F. C. Craighead
Washington
D. C.

Dear Dr. Craighead:

There is enclosed copy of a memorandum by W.D.Bedard relative to the winter killing of pine foliage. This report was based upon data taken from sample plots established in the spring of 1936 for the purpose of recording the relationship between defoliation of this character and subsequent insect damage. Though no insect attacks were recorded in any of the marked trees, this memorandum was prepared to record some of the effects of defoliation on survival and growth because of the important bearing which these factors have in entomological problems. Your comments will be appreciated.

Copies have been sent to Mr. Miller, Mr. Keen, and Mr. Beal; and to the Director of the Northern Rocky Mountain Forest Experiment Station.

Respectfully yours,

James C. Evenden
Entomologist

Enclosure

Memorandum for the files

Re: Winter Killing of Pine Foliage

During October and November 1935, a period of low temperatures occurred throughout most of the northern Rocky Mountain region, and although the temperatures were not extreme, they were preceded by higher temperatures well within the range required for plant development. In the vicinity of Coeur d'Alene, Idaho, the cold weather occurred following a maximum of 48 and a minimum of 41 on October 28th. During the next six days the maximum remained below freezing and the minimum went as low as 0° F. on November 1st. As a result of the freeze a considerable amount of pine foliage was killed wherever the sudden drop in temperatures had occurred.

On May 13, 1936, two sample plots[1] were established in defoliated white pine reproduction near Mullan, Idaho, to determine if the effect of defoliation would result in subsequent insect damage to the trees. On May 19, 1936, a third plot[2] was established in mature white pine in the Twelvemile Creek drainage of the Cabinet National Forest. In addition, 21 white pine trees[3] were marked in the Clay Creek and Rampike

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[1] Plots established by H. J. Rust and W. D. Bedard. Examined October 13, 1936, by J. C. Evenden and W. D. Bedard

[2] Plot established by T. T. Terrell, H. J. Rust, and W. D. Bedard. Examined October 13, 1936, by J. C. Evenden and W. D. Bedard.

[3] Marked by T. T. Terrell and Examined Nov. 4, 1936, by T. T. Terrell and W. D. Bedard.

Creek drainages of the Coeur d'Alene National Forest, and 40 ponderosa pine trees[1] were marked in the vicinity of Coeur d'Alene, Idaho.

Although no insect attacks have appeared in any of the trees during the first season subsequent to the defoliation, this memorandum has been written to record some of the effects of the defoliation on survival and growth because of the important bearing which these factors have in entomological problems. For convenience the memorandum has been divided into three sections to include (1) white pine reproduction, (2) mature white pine and (3) mature ponderosa pine.

White Pine Reproduction

Data for western white pine reproduction were secured from two sample plots, one near Mullan, Idaho, and the other in the pass at Lookout Summit. These plots include a total of 78 trees, which ranged in defoliation from zero to 100 percent. At the time the plots were established in May, the following data were recorded: Height of tree, dominance, percent defoliated, and percent bud mortality. When the examination was made in October, the length of the 1936 leader was compared with that of the 1935 leader, and the length and volume of 1936 needles were recorded.

Figure 1 is a photograph of plot #1 taken with an orange A filter and panchromatic film, so that the defoliated trees appear white

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1 Marked by H. J. Rust and examined by him November 4, 1936.

in the photograph. Table I shows the defoliation recorded on the trees visible in the photograph.

TABLE I
PERCENTAGE DEFOLIATED ON TREES SHOWN IN FIGURE ONE

Tree number	751	752	758	761	762	764	765	766	767	768
Percent defolia-tion	71-80	91-100	61-70	71-80	100	21-30	81-90	11-20	61-70	0-10

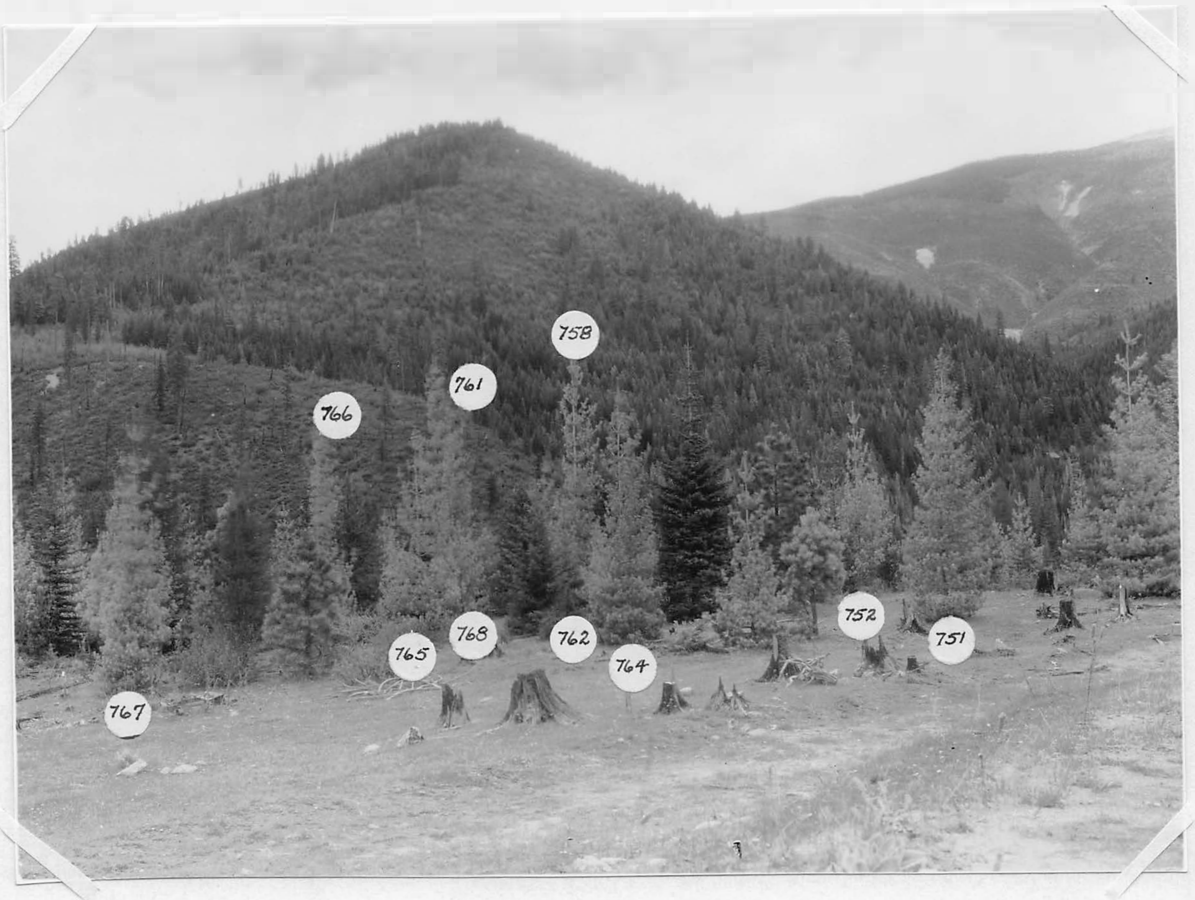

Fig. 1 - View of Plot #1. Note light color of defoliated trees compared with adjacent undefoliated trees and green background.

Figures 2, 3 and 4 show trees which suffered different percentages of defoliation and bud mortality. Tree 768 showed ten percent defoliation and no bud mortality. This tree had completely recovered at the time of the fall examination. Tree 751 showed 71-80 percent defoliation and 50 percent bud mortality, and had made no leader growth during the 1936 season. One hundred percent of the foliage and over 90 percent of the buds on tree 762 had been killed, and at the time of the fall examination this tree showed very sparse foliage with one-third of the upper portion of the tree dead.

Fig. 2 - Tree #768

Fig. 3 - Tree #751

Fig. 4 - Tree #762

In general, the injury resulting from the defoliation was not as severe as anticipated. Of all the trees on the two plots only one was recorded as dead at the time of the fall examination. Two trees, however, possessed dead leaders and very sparse foliage and may succumb during another season. Three other trees were sparsely foliaged and showed no 1936 leader growth.

One of the most outstanding features of the defoliation is the variation in severity even within one small sample plot. Obviously, all the trees within such a plot must have been subjected to nearly the same temperatures, and thus the answer must lie in the physiological condition of individual trees at the time of the freeze. Table II has been prepared to show the differences in injury and recovery on both plots as a result of tree height. In making the examination the 1935 foliage was considered normal and the 1936 needles were compared with this on the basis of density and length. Recovery is expressed in percentages to show how the 1936 needles compare with 1935 foliage, and the length of the 1936 leader compared with leader growth in 1935.

TABLE II
VARIATION IN INJURY AND RECOVERY AS A RESULT OF HEIGHT

Tree height	Trees examined	Defoli-ation	Bud mortality	Recovery	
				Foliage	1936 leader
feet	number	percent	percent	percent normal	percent of 1935 leader
6-15	48	21.0	8.7	89.1	62.5
16-25	17	44.1	2.3	86.6	66.3
26+	12	56.6	35.7	79.1	36.8

Although there is a slight irregularity in bud mortality and leader growth for those trees from 16 to 25 feet in height, in general the taller trees suffered the greatest injury and showed the least recovery. In explanation of this it may be said that all trees were more severely defoliated at the top than at the base. There are at least three possible reasons why greater defoliation occurred at the

top of the tree. Physiologically, the lower branches should be the first to prepare themselves in response to lower temperatures both from the standpoint of shorter conducting tissue as well as lower photosynthetic rate. Climatically, the lower branches should be in a somewhat warmer environment owing to the protection afforded by surrounding trees. In addition, it is possible that radiation from the earth may have provided some protection.

Table III shows the correlation when injury and recovery are compared with tree dominance. This table includes all trees on both plots.

TABLE III
VARIATION IN INJURY AND RECOVERY AS A RESULT OF DOMINANCE

Dominance	Trees examined	Defoliation	Bud mortality	Recovery	
				Foliage	1936 leader
	number	percent	percent	percent normal	percent of 1935 leader
Dominant	31	34.1	13.8	87.5	59.5
Co-Dominant	27	17.7	4.0	90.8	61.1
Suppressed	19	26.8	17.8	80.0	56.0

It appears that this table is somewhat of a contradiction to table II, because the dominant trees do not appear to have suffered the severe damage which was noticeable in the tallest trees in table II. In explanation of this apparent discrepancy one must consider the differences in the two plots from which these data were taken. Plot #1 contained taller trees than plot #2, and defoliation was also more severe on plot #1. Hence, on the basis of height the taller trees would appear to have suffered a decidedly heavier damage. On the basis

of dominance, however, both plots are given equal weights because the tallest trees in plot #2 are grouped with the tallest trees in plot #1, etc.

Table III, therefore, shows that dominant trees suffered the most defoliation, with the suppressed trees second in amount of defoliation and the co-dominant trees having suffered the least defoliation. The suppressed trees, however, lost the most buds, the dominants next in amount of bud mortality, and co-dominants last. As would be expected, the co-dominants having had the least injury made the greatest recovery. The dominants, however, in spite of having suffered the greatest defoliation made a better recovery than did the suppressed trees. This is probably explained by the fact that the dominants had less bud mortality and are more vigorous than the suppressed trees.

In general, the recovery in all trees was directly proportionate to the amount of injury as shown in table IV.

TABLE IV
COMPARISON OF RECOVERY WITH AMOUNT OF INJURY

Percent bud mort.	Percent defoliation					
	0-50			51-100		
	# trees	% norm.fol.	% 1935 leader	#trees	% norm.fol.	% 1935 leader
0-50	64	93.3	67.0	5	93.3	34.0
51-100	0			8	30.0	11.1

It is quite apparent in table IV that the defoliation and bud mortality on most of the trees was less than 50 percent, and that the

amount of recovery was less in those trees suffering the greatest injury. Although only one tree in the severest injury group had died at the time of the examination, it is believed that a few more will die and a number of the others may be permanently deformed.

Mature White Pine

This group includes 41 large trees, 20 of which were in the Twelvemile Creek drainage of the Cabinet National Forest, 7 in the Steamboat Creek drainage of the Coeur d'Alene National Forest, and 14 on the divide between Rampike and Cabin Creeks on the Big Creek drainage also on the Coeur d'Alene. Because of the large size of these trees the injury was determined by an estimate of the amount of defoliation, and the recovery judged by the amount of growth during the 1936 season as shown by increment cores.

TABLE V
COMPARISON OF 1935 AND 1936 GROWTH ACCORDING TO DEGREE OF DEFOLIATION

Defoliation percent	Trees examined number	Average width 1935 ring mm	Average width 1936 ring mm	Percent 1936 ring is of 1935 ring percent
0-20	22	1.29	1.14	88.3
21-40	6	.91	.50	54.9
41-60	7	.91	.54	59.3
61-80	2	1.69	.58	34.3
81-100	4	.40	.11	27.5

Table V shows that less than 50 percent of the trees suffered more than 20 percent defoliation. It is also apparent that recovery is

directly dependent on the amount of defoliation. Although average growth in undefoliated trees during 1936 was somewhat less than in 1935, trees with less than 20 percent defoliation made 88.3 percent of the 1935 growth, while trees with more than 80 percent defoliation grew only 27.5 percent as much in 1936 as they did in 1935.

Table VI shows the percent of defoliation and the recovery according to the rate of tree growth.

TABLE VI
INJURY AND RECOVERY BASED ON RATE OF GROWTH

Average width last 10 rings	Trees examined	Average defoliation	Average width 1935 ring	Average width 1936 ring	Percent 1936 ring is of 1935 ring
mm.	number	percent	mm	mm	percent
over 2.01	4	18	2.77	1.92	69.3
1.51-2.0	5	14	1.66	1.26	75.9
1.01-1.5	10	22	1.26	.95	75.3
.51-1.0	13	28	.77	.61	79.2
0-0.5	9	51	.37	.24	64.8

The main feature of table VI is that, although the amount of injury was progressively greater from the most rapid to the slower-growing trees, the latter made the greatest recovery, except those trees which had suffered more than 50 percent defoliation.

In explanation of this apparent contradiction, it is possible that the more rapidly growing trees with their more abundant conducting tissues are able, under sudden climatic changes, to make a more rapid translocation or change of materials than are the trees of

slower growth. Thus they are able to avoid the disastrous effects of the freeze. When growth is resumed, however, following the low temperatures, those trees growing under optimum conditions would naturally show a greater reaction to foliage loss than would the more slowly growing trees. This has been shown to be true in cases of drought and insect defoliation. Obviously, there is a point at which the effects of the loss of foliage must be shown by even the slowest-growing trees, as shown in table VI.

Mature Ponderosa Pine

All mature ponderosa pine trees were in the vicinity of Coeur d'Alene, Idaho, and in general were much more severely defoliated than either the mature white pine or white pine reproduction. Table VII gives a comparison of the 1935 and 1936 growth according to the percentage of defoliation.

TABLE VII
COMPARISON OF 1935 AND 1936 GROWTH ACCORDING TO DEFOLIATION

Defoliation	Trees examined	Average width 1935 ring	Average width 1936 ring	Percent 1936 ring is of 1935 ring	Trees with no ring in 1936
percent	number	mm	mm	percent	
0-20	2	3.03	1.66	54.7	
21-40	4	2.65	1.91	72.0	
41-60	21	2.11	1.22	57.8	
61-80	13	1.29	.27	20.9	9

Table VII shows that most of the ponderosa pine lost more than 50 percent of their needles. In this table it is again apparent that the amount of recovery is not entirely dependent upon the amount of injury. Hence table VIII has been prepared to show the percent of defoliation and recovery according to the rate of tree growth.

TABLE VIII
INJURY AND RECOVERY BASED ON RATE OF GROWTH

Average width last 10 rings	Trees examined	Average defoliation	Average width 1935 ring	Average width 1936 ring	Percent 1936 ring is of 1935 ring	Trees with no 1936 ring
mm	number	percent	mm	mm		
over 4.01	3	42	5.80	2.88	49.6	
3.01-4.0	4	47	3.67	1.77	48.2	
2.01-3.0	7	48	2.48	1.36	54.8	
1.01-2.0	15	58	1.47	.85	57.8	3
0-1.0	11	64	.58	.28	48.2	6

Here again it is apparent that greatest injury occurred to the slower-growing trees, but that with the exception of the severest-defoliated trees, greatest recovery was made by those trees making slow growth.

SUMMARY

1 - Sudden freezing temperatures during October 1935 resulted in the death of pine foliage.

2 - As a result of this defoliation sample plots were established in white pine reproduction and mature white and ponderosa pine to determine if the defoliation would result in increased insect activity.

3 - To date no insect attacks have been made in any of the defoliated trees marked for examination.

4 - In white pine reproduction the dominant trees suffered the greatest amount of injury, but also made the most recovery.

5 - In mature ponderosa and white pine the greatest injury occurred in those trees making the slowest growth. Recovery, on the other hand, was greatest in the slower-growing trees, except when defoliation was so severe as to prevent any great recovery.